Aquarius Sea Surface Salinity Observations for Global and Regional Studies: Error Analysis and Applications

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The Aquarius/SAC-D satellite provides an opportunity to observe near-global sea surface salinity (SSS) with unprecedented space and time resolution. In order to evaluate and quantify the potential utility of the SSS data for global and regional studies of SSS variability, our research group has been using the Level-2 (current version 2.7.1, soon to be version 3.0), three-beam swath data and Argo data to characterize and quantify random errors and systematic biases on a global grid and as time-series. Analyses address: global, regional and temporal Aquarius-Argo differences; and Aquarius inter-beam biases including spectral characterization of RMS errors. To infer the statistical structure of the inter-beam biases, we compare statistics of inter-beam differences as seen by HYCOM (ancillary SSS) and those evaluated from Aquarius data.

1. Aquarius-Argo SSS differences

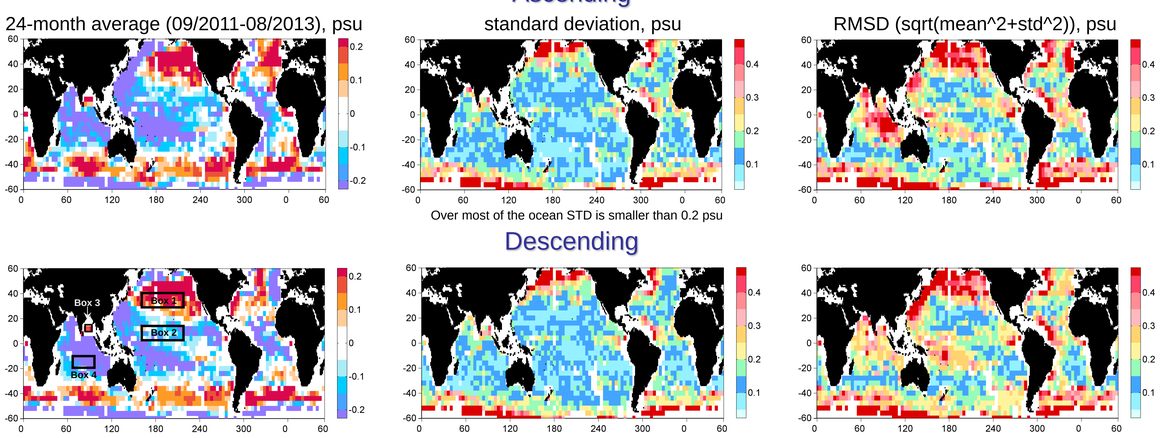
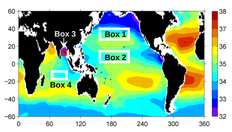


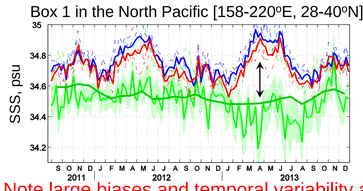
Figure. Statistics of Aquarius-Argo SSS differences: mean (left), standard deviation (middle) and RMSD (right) of 24 monthly mean Aquarius-Argo difference maps for ascending (upper) and descending (lower) satellite SSS data. Monthly maps of the differences were constructed by bin-averaging of Aquarius (Argo) data within 8ºx8º bins centered on a global grid with the grid spacing of 4º.

2. Regional examples



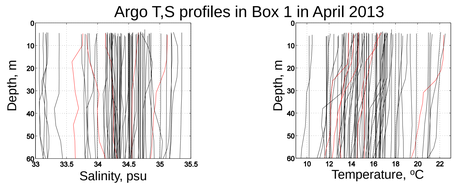
Figures (2a) | **Figures (2b)**

Box 1 in the North Pacific [158-220ºE, 28-40ºN]



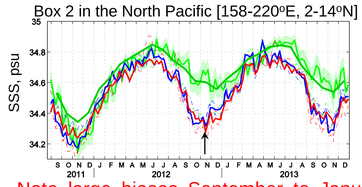
Note large biases and temporal variability and differences in Argo products (sampling?).

Argo T,S profiles in Box 1 in April 2013



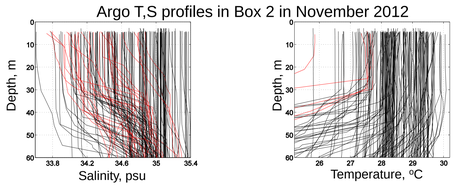
Argo profiles show a well-mixed layer.

Box 2 in the North Pacific [158-220ºE, 2-14ºN]



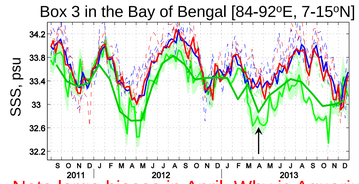
Note large biases September to January. Is Aquarius fresher due to stratification?

Argo T,S profiles in Box 2 in November 2012



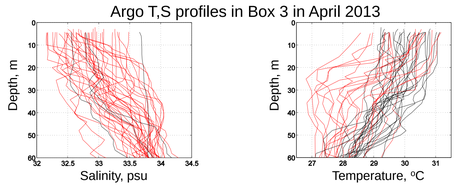
Near-surface stratification is an issue.

Box 3 in the Bay of Bengal [84-92ºE, 7-15ºN]



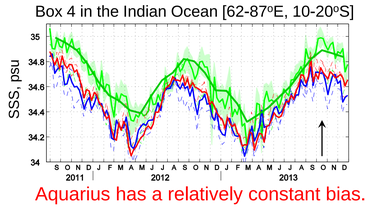
Note large biases in April. Why is Aquarius saltier in this region?

Argo T,S profiles in Box 3 in April 2013



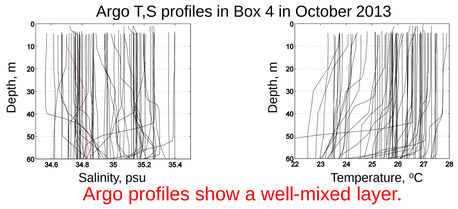
Near-surface stratification is an issue.

Box 4 in the Indian Ocean [62-87ºE, 10-20ºS]



Aquarius has a relatively constant bias.

Argo T,S profiles in Box 4 in October 2013



Argo profiles show a well-mixed layer.

Figure 2. **(a)** Time-series of weekly box-averaged Aquarius and Argo data. Light green line shows weekly Argo mean with shading indicating the standard error. Heavy green line shows the weekly Argo mean calculated from the gridded APDRC Argo product available at http://apdrc.soest.hawaii.edu/. Solid red and blue lines show weekly Aquarius mean SSS from ascending and descending tracks. Dashed/dotted green, red and blue lines show the individual beams. **(b)** Argo T,S profiles in each box indicate stratification conditions in the near-surface layer. Red profiles show near surface property gradient (stratification): S(30 m) - S(5 m) > 0.1 psu or T(5 m) – T(30 m) > 1ºC.

3. Aquarius Inter-beam biases

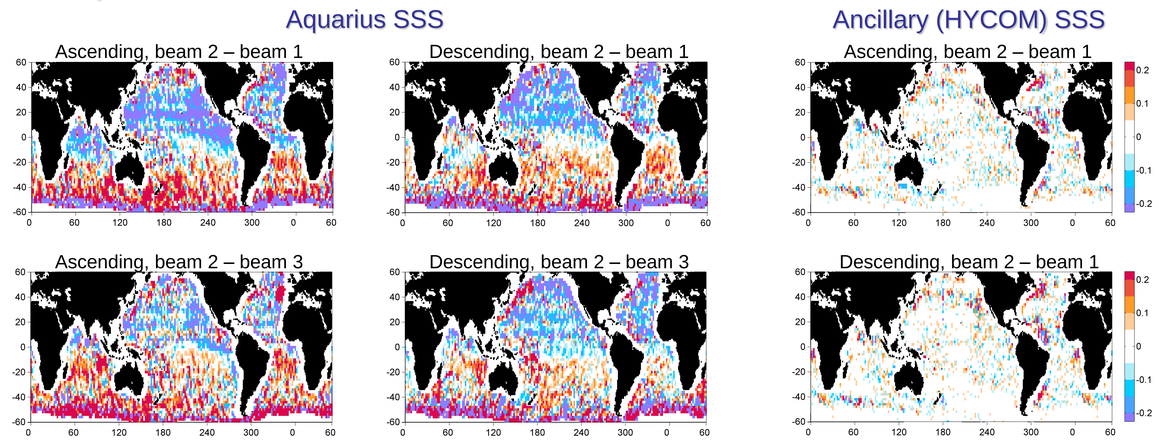
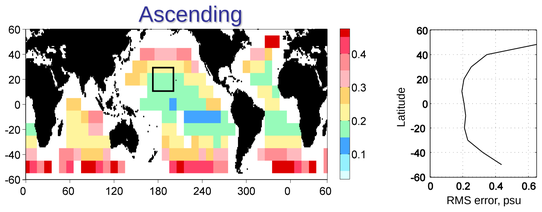


Figure 3. Global maps of inter-beam SSS differences from Aquarius observations averaged over the month of September 2012. Upper: SSS of beam #2 (middle beam) minus SSS of beam #1 for ascending and descending satellite passes. Lower: SSS of beam #2 minus SSS of beam #3. Units are psu. The inter-beam SSS differences are computed by differing SSS fields constructed by bin-averaging of raw Aquarius data (each beam separately) within 4ºx4º bins centered on a global grid with grid spacing of 2º. For comparison, the inter-beam SSS differences from ancillary (HYCOM) SSS data are shown on the right.

Inter-beam differences are computed for each ground track as SSS of the middle beam minus SSS of the two other beams. Covariances of the inter-beam differences are computed as a function of along-track separation and averaged to obtain the ensemble statistics. The ancillary data are processed in exactly the same way. The estimation of the inter-beam bias statistics is accomplished by comparing the covariances of the inter-beam differences for Aquarius and ancillary SSS. RMS inter-beam bias errors are adjusted for the observed HYCOM signals.



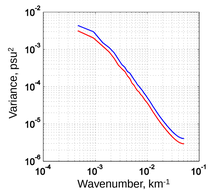


Figure 4. Auto-spectra of inter-beam biases computed from the data of the North Pacific (190-210ºE, 10-30ºN; black rectangle in Fig. 5). Red and blue curves represent Aquarius ascending and descending data, respectively.

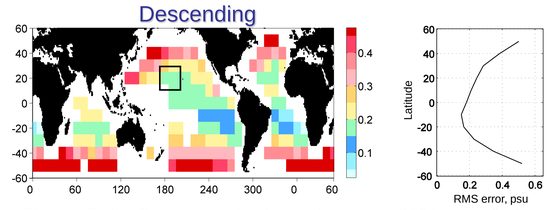


Figure 5. RMS error of inter-beam biases in 20º boxes (left panels); zonal averages of RMS error (right panels).

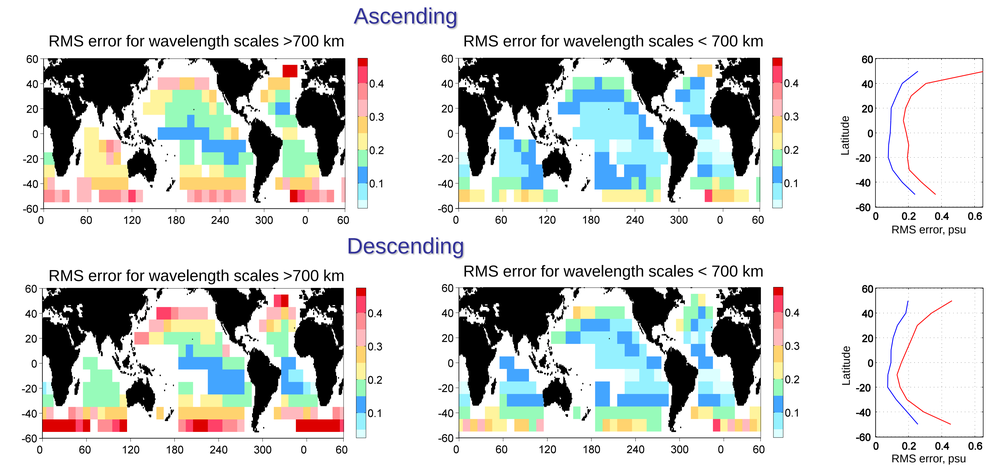


Figure 6. RMS error of inter-beam biases in 20º boxes for wavelengths > 700 km (left panels) and wavelengths < 700 km (center panels). Zonal averages of RMS error in wavelength bands (> 700 km, red) and (< 700 km, blue) are in right panels.

4. Conclusions

- Aquarius-Argo standard deviation over most of the ocean is smaller than 0.2 psu for the first 2 years of gridded monthly mean differences.
- Aquarius-Argo regional and temporal differences are still present and significant, and need further study.
- Aquarius inter-beam biases are significant globally with increasing magnitude at higher latitudes; dominant wavelengths contributing to biases are for scales > 700 km.
- Despite continuing Level-2 product improvement of Aquarius SSS data, significant biases persist. These biases can produce errors in real temporal variability and absolute value of SSS estimates, and need to be quantified as part of research projects.

Acknowledgments. We thank NASA Physical Oceanography Program for financial support of this study through grant NNX09AU75G and grant NNX12AK52G. We acknowledge the use of freely available Argo data collected by the International Argo Project and the national programs that contribute to it (http://www.argo.ucsd.edu).